JOURNAL

OF THE

SCIENTIFIC LABORATORIES

DENISON UNIVERSITY

Volume 44 **Articles 12–17** **Pages 203 to 254**

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Permanent Secretary Denison Scientific Association

GRANVILLE, OHIO

June, 1958

This *Journal* is published under the joint sponsorship of Denison University and the Denison Scientific Association.

JOURNAL OF THE SCIENTIFIC LABORATORIES OF
DENISON UNIVERSITY

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STIMULUS VARIABLES IN APHASIA: I. SETTING CONDITIONS[1]

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I. INTRODUCTION

A. *Historical Background*

From the published literature it appears that a minimum of original research with aphasic phenomena is being done by individuals trained as psychologists. The few reviews that appear, for example, in textbooks of abnormal psychology, consist primarily of summaries of the best known treatises on the subject. Original investigation is almost exclusively the work of neurologists. Perhaps as a result attention is directed to the neural factors among the conditions to which one might give consideration in studying aphasia.

Historically two principal trends may be noted. In the first, the primary concern is with nervous system function. Speech behavior is studied following trauma for what can be learned about localization. The work of Broca, Wernicke, Henschen, Bastian and others is representative.

The second group, represented by Jackson, Head, Goldstein, and Weisenburg and McBride, focuses attention upon behavior, attempting more refined descriptions of aphasic phenomena. Again the primary correlation is with alteration in neural structure.

Such factors as stimuli, setting and individual history, are treated with varying degrees of indifference by the adherents of either of these points of view. The studies follow a more or less similar pattern. An individual's language behavior is studied by some testing procedure. On the basis of a general picture of his performance in terms of successes and failures, perhaps only in one examining period, a diagnostic label is applied. This in turn is correlated with the organic (brain) status of the patient. It is true that some investigators note inconsistencies. An individual unable to write the name and address of his mother does write his own (the same); a "speechless" patient yells "Fire" in a burning building. These are regarded as interesting exceptions with no attempt to account systematically for them. This emphasis on explanatory neurologizing is consistent with traditional neurological (and psychological) thinking; by the nature of their practice, neurologists see cases with dramatic symptoms originating with the predominant antecedent condition of some cortical truncation.

Investigators vary in their respect for careful experimental or constructional

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methodology. Most reports are based simply on collections of clinical studies without the use of experimental controls. In theory construction the influence of the neurological tradition is omnipresent. For example, in a study by Neilsen and Raney (15) of aphasic patients with left temporal lobe lesions who improve with temporal lobectomy, they simply conclude that engrams for speech also must be present in the minor hemisphere.

On the matter of classificatory schemata there is nothing but confusion. New "types" are constantly presented which undoubtedly overlap previous ones. Some are anticipated and later "found" on the basis of the diagrams of the localizationists. There is controversy regarding the existence of "pure" types. There are attempts to make classifications relatively specific. Others, like Head (8) and Weisenburg and McBride (17), prefer more general and inclusive rubrics.

The present problem for investigation derives not only from the mentioned limitations of the work reported, as well as direct observations of aphasic behavior, but also from the study of normal linguistic behavior. This quotation from Esper (5) is pertinent:

> "A serious fallacy which seems implicit in much pseudo-psychological theorizing in the field of linguistics consists in the assumption that linguistic material can be studied without reference to the stimulus settings in which it occurs. This assumption proceeds from the notion of language as being the "expression of ideas". Actually, I do not see how we can escape the view that language, in its fundamental living form consists of a system of verbal responses to (chiefly external) stimulus patterns, closely interrelated with the patterns of manipulative behavior. The fundamental unit to be investigated is not a purely grammatical one, but a stimulus-response unit. . . . It is from a study of the conditions determining these changes in S-R relationships that we may hope to arrive at the principles of linguistic change and linguistic organization."

The more immediate derivation of the present study comes from Kantor's interbehavioral system (10, 12). Most relevant here are his emphasis upon the field approach to behavioral study, his participative principle in the relationship of structure to behavior, and his descriptions of linguistic behavior. Language events are isolated from other behavioral events primarily on the basis of their referential character and the nature of stimulus participation. Conditions for possible manipulation and correlation with behavior include object spoken about, person spoken to, setting, immediate context of the stimulus, the individual's behavioral history, conditions facilitating attention to the stimulus, immediately preceding behaviors, and so forth. These may be studied, holding constant the lesional status of the subject, to determine their effectiveness in response elicitation (presence or absence of appropriate response or its quality). Each may be investigated individually in a manner similar to the traditional association of the behavior with the lesion, but with the caution, however, that the behavior is not necessarily a simple function of any one condition. In fact there would be no necessity for denial of the previously acquired knowledge of biological participation. It might not retain, however, its predominant contemporary status of a simple cause in the understanding of language pathology. Our point of departure is always behavior, understanding it in terms of all the

variables operative in the language field—not just the neural ones. No neural traces nor faculties are posited.

B. *Problem*

For the immediate investigation it was decided that the variable of stimulus context should be studied. Toward understanding the problem both from the point of view of speaker and hearer the following statement of intention arose: To study the possible effect of variation in the context of the adjustment stimulus (object referred to) upon (A) evocation and (B) understanding of speech.

For example, in the first case will the aphasic be able to name an object pointed to more frequently when that object appears before him in an appropriate (familiar) arrangement of stimuli than when it does not? More specifically, can an ashtray be named more frequently when it appears on a desk than upon the floor?

In the second case, will the aphasic find it easier to understand speech when the adjustment stimulus is present in an appropriate (familiar) arrangement of stimuli than when not? For example, will the individual understand, "Show me the ashtray" more easily when it appears on the desk than when on the floor? In this second problem there is a complication in that in testing speech understanding an additional behavioral unit, pointing to the object, is required.

II. PROCEDURE

A. *Subjects*

Eleven individuals whose aphasic status was confirmed either by a medical examiner or a speech pathologist were used as subjects. Traditional criteria were used, namely, speech difficulty associated with cerebral trauma and without paralyses which would account for the speech difficulty. Four subjects not meeting these criteria were rejected.

Identifying information was obtained from hospital records, family, and other sources. The Eisenson *Examination for Aphasia* was administered when possible (3).

Table I presents a summary of the principal characteristics on which comparisons could be made. Because of the sources the information must be regarded as approximate. Furthermore, some of the entries involve judgments made by the experimenter on the basis of his observations. For example, the pre-morbid ability level of the subjects was estimated from education, occupation and other factors. All but one of the patients (Ci, born in Lithuania) were natives of this country. None of the others was known to have spoken with fluency any language but English. Ci had spoken Lithuanian, Spanish, Yiddish and English.

Medical examination indicated all patients had some sort of brain pathology at the time of onset. Four of these were of traumatic origin and seven were vascular in nature.

Approximations of the years since onset of difficulties are indicated. These

TABLE I

Description of Subjects

Subject	Age	Sex	Race	Education	Est. Ability	Brain Damage	Years Aphasic	Handedness	Diagnosis	Severity	Ambulatory	Employed	Studied at:	Efficiency ranking	Former Occupation
Wh	67	M	W	8	A	V	8	R	E-R	Sev	No	No	R	10	Housepainter
Gl	38	M	W	12	A	T	7	R	E-R	Mod	Yes	Semi	C	4	Cabinet maker
Hu	70	F	W	12	A	V	1	R	E-R	Sev	No	No	R	8	Housewife
Va	73	M	W	8	A	V	1.5	R	E-R	Mod Sev	Yes	No	R	6	Steamfitter
Da	32	M	W	16	AA	T	3	R	R	Mod	Yes	No	C	2.5	Journalist
El	49	M	W	8	AA	T	9	R	E	Mild	Yes	No	C	5	Warehouse Supt.
Ci	37	M	W	8	AA	V	7	R	E	Mod	Yes	Yes	R	1	Watchmaker
Le		M	N		A	V	1	R	E-R	Sev	No	No	H	9	Musician (?)
Ob	25	M	W	9	A	T	4	R	E	Mild	Yes	No	H	2.5	Semi-skilled laborer
Se	61	M	W	6	BA	V	1.5	R	E-R	Sev	No	No	H	11	Poolroom attendant
No	36	M	W		A	V	2	R	E-R	Mod Sev	Yes	No	H	7	?

A, average; AA, above average; BA, below average; V, vascular; T, traumatic; E, expressive; R, receptive; E-R, expressive-receptive; R, home; C, clinic; H, hospital.

ranged from six months to nine years. All subjects had been right handed. Some attempt was made to represent aphasic diagnoses according to the Weisenburg-McBride method of classification together with indications of the severity of language impairment. In no way could we speak of any "pure" types, and the designations are made with little confidence.

Seven patients were ambulatory, four required wheel chairs, but none was seen in bed. One patient was employed as a watchmaker. One could be considered semi-employed as he worked part-time in a Goodwill Industry. One (Ob) recorded as not employed was attending school part of each day. The experiment was conducted in the homes of four of the subjects. Three were seen in the offices of a clinic. Four were seen in hospital offices, although two of these (Ob and No) were ambulatory out-patients. The principal occupations of the subjects before the onset of aphasia are listed.

The "efficiency ranking" was made by the experimenter from various direct observations and information obtained from the histories. Criteria included ability to walk, self feeding, ability to light and smoke a cigarette, pursuit of gainful employment, stamina, ability to move about the neighborhood and community for self entertainment or business, being trusted to drive an automobile, and so forth. Obviously, the ratings are crude and made only by the experimenter who was the only individual to contact all the patients. The rankings are from one to eleven, the number of subjects in the group.

B. *Experimental Procedure*

Because no criteria of severity or sub-type of disorder were involved in selection, considerable variability of dysfunction was to be expected in our aphasic population. The level of difficulty of tasks could have been adapted to each subject but this would have produced data unsuited for combining. Instead tasks judged to be of average difficulty for aphasics were used for all subjects. This plan was adopted although lack of differentiation between the control and experimental situations for either or both the mildly or severely disordered subjects was anticipated. In the first instance complete success in each situation and in the latter complete failure in both the control and experimental situations were possibilities.

Part A. *Verbo-vocal Speech*

Each subject was presented with a series of twelve stimulus objects, pieces of a table setting, in two different contexts. The objects included a knife, fork, spoon, cup, saucer, dinner plate, cream pitcher, sugar bowl, glass, paper napkin, and glass salt and pepper shakers. The latter two objects were each half-filled and the contents, of course, were visible. In the control situation these appeared on a table cloth in a disarrayed, but constant order. They were in two rows of six objects each occupying a rectangular space approximately eighteen by twenty-four inches (Figure 1). In the experimental situation they appeared on a table cloth in their familiar or appropriate relationships (Figure 2). The experimenter pointed to each of the twelve objects in the series and asked the question, "What is that?".

There was alternation between the experimental and control presentations following the usual orderings at each sitting. Thus the first subject for the first

Fig. 1. Control setting

FIG. 2. Experimental setting

day followed the procedure CEEC, the second day ECCE, the third CEEC, etc. The second subject was begun with the order ECCE, etc. There was a total of six such sessions for each subject. This permitted a total of twelve presentations each of the control and experimental series of stimuli. After the presentations of the first two series of stimuli in each session a brief rest period was allowed. The time was spent conversing or smoking.

Two orders for the presentation of individual stimuli were utilized; the second was merely the reverse of the first. The forward order was as follows: knife, salt shaker, napkin, fork, pepper shaker, sugar bowl, saucer, glass, cream pitcher, spoon, cup, plate. The same order was used for the first two presentations within a session (one control and one experimental series) but systematically varied from day to day for the same subject and between subjects.

Approximately 15 seconds were allowed for a response, and responses beyond that limit, even if correct, were considered failures. If a response was given in less than the permitted time the next stimulus was presented without waiting for the allotted time to elapse.

An attempt was made to have approximately a full day between each of the experimental sessions. This plan could not be adhered to in some instances because of a subject's employment, week-end excursions, or hospital schedules.

Some difficulty in evaluating responses was encountered. Decisions regarding scoring may be considered arbitrary and the results must be interpreted in terms of the procedure followed. The details are omitted here but may be found in another report (20).

Part B. *Understanding Speech*

In this second half of the experiment subjects, experimental-control ordering, stimulus objects, contextual setting of stimuli, order of presenting stimuli,

methods of recording behavior and other features were identical with those of Part A except for the following: Understanding rather than speaking was being studied so that instead of asking the subject, "What is that?", while pointing to one of the objects, the instruction was, "Show me the ————". Four presentations of the series of stimuli for Part B for each sitting always followed the completion of Part A. When subjects asked for a repetition of the instruction it was given.

Scoring problems were much simplified for this part of the experiment. Responses involved either pointing to the objects on the table or lifting them. The subjects restricted themselves to twelve possibilities as opposed to the unlimited number of responses which might be made in the speaking or naming situation. In fact, in only six out of nearly three thousand of these responses did a subject fail to select some object in the series. In these instances he could not "find" them. The only difficulty that sometimes presented itself in scoring here was when vacillation was displayed. A subject would alternate fork-knife-fork-knife-fork or might point to several different objects. Regardless of the preceding behaviors involved, the final choice was the one scored.

III. RESULTS AND DISCUSSION

Table II presents a summary of the *correct* response frequency for each stimulus object for our group of eleven subjects in Procedure A (Speaking). Comparison is made between the results obtained in the control and experimental situations, the difference, the mean difference, and t values. The standard error of the mean difference was obtained by using the formula for small samples described by Edwards (2) which takes account of the correlated nature of the data. Table III presents a similar summary of the *correct* response frequencies for the data from Procedure B (Understanding). In this, the subject pointed to the object as instructed by the experimenter. It was impossible to complete all

TABLE II

Correct response frequencies in control and experimental situations of Procedure A (Naming).
(11 subjects, *df* 10)

	Stimulus																									
	Kn		Sa		Na		Fo		Pe		SB		Sr		Gl		CP		Sp		Cu		Pl		Total	
	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E
Total	62	63	58.5	67.5	67	63	74	75	72.5	75.5	66	69	53.5	56.5	56.5	60	53	56	68.5	75	57	60	62	61	750.5	781.5
E-C	1		9		−4		1		3		3		3		3.5		3		6.5		3		−1		31	
Mean	.09		.82		−.36		.09		.27		.27		.27		.32		.27		.59		.27		−.09		2.82	
σm_d	.46		.38		.59		.28		.30		.25		.30		.17		.30		.26		.30		.09		.97	
t	.19		2.16		.61		.32		.90		1.20		.90		1.90		.90		2.27		.90		1.00		2.8	
p																			$<.05$						$<.05$	

C, control; E, experimental; Kn, knife; Sa, salt; Na, napkin; Fo, fork; Pe, pepper; SB, sugar bowl; Sr, saucer; Gl, glass; CP, cream pitcher; Sp, spoon; Cu, cup; Pl, plate.

TABLE III

Correct response frequency in control and experimental situations of Procedure B (Understanding). (11 subjects, *df* 10)

	Stimulus																							
	Kn		Sa		Na		Fo		Pe		SB		Sr		Gl		CP		Sp		Cu		Pl		Total	
	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E
Total	104	99.5	101.5	107.5	124	126	87.5	109	101	104	88.5	96.5	85.5	78	94.5	117	92.5	99.5	92	97	78	81	111	105	1160	1220
E-C	−4.5		6		2		21.5		3		8		−7.5		22.5		7		5		3		−6		60.0	
Mean	−.41		.55		.18		1.95		.28		.73		−.68		2.05		.64		.45		.27		−.55		5.45	
σm_d	.41		.34		.18		1.02		.30		.59		.47		.80		.49		.66		.24		.41		1.60	
t	1.0		1.6		1.0		1.89		.93		1.2		1.5		2.56		1.3		.68		1.1		1.34		3.41	
p															$<.05$										$<.05$	

C, control; E, experimental; Kn, knife; Sa, salt; Na, napkin; Fo, fork; Pe, pepper; SB, sugar bowl; Sr, saucer; Gl, glass; CP, cream pitcher; Sp, spoon; Cu, cup; Pl, plate.

sittings for one subject and his results were pro-rated, multiplying by 1½. This accounts for the half values in the tables.

Examination of Table II reveals differences favoring the experimental procedure for ten of the twelve objects used. Only one of these (spoon) is significant at the 5% level of confidence. Perhaps the lack of statistical significance may be a function of the small number of cases involved, and probably even in the case of one significant difference interpretative comment is not warranted. In the case of the data for Procedure B (Understanding) differences favoring the experimental procedure occur for nine of the twelve objects (Table III). Again only one (glass) produces a difference significant at the 5% level of confidence.

In Table IV may be seen the difference between control and experimental results for individual subjects. It will be noted that in several instances there are zero differences. Subjects either obtained maximum or near-maximum or minimum or near-minimum values in both situations. Thus, the small differences may be a function of the limited range of difficulty of the test items. In all but one instance the difference was either zero or in favor of the experimental hypothesis.

The obtained *total* differences for all stimuli combined and their significance ratios negate the null hypothesis that they are due to chance at the 5% and 1% levels of confidence for the A (Speaking) and B (Understanding) procedures respectively. The contrived difference between the two situations was the presentation of stimuli in context in the experimental situation. The findings would support the hypothesis that more than the structural status of the organism is of importance in understanding the presence or absence of the language behavior in the aphasic. This would be true regardless of whether or not there is agreement upon the stated difference of context.

While the foregoing presents the principal findings for which this research was designed, other observations are worthy of mention. Analysis demonstrated a selectivity of errors related to the stimulus. Similarity of form, use, color,

TABLE IV

Correct response frequencies in the control and experimental situations for individual subjects, the totals ("performance level"), and the difference score (E-C)

	Procedure A				Procedure B			
Subj.	C	E	Total	E-C	C	E	Total	E-C
Wh	0	0	0	0	55	69	124	14
Gl	30	37	67	7	120	124	244	4
Hu	0	0	0	0	95	106	201	11
Va	115	125	240	10	131	133	264	2
Da	134	136	270	2	139	141	280	2
El	144	144	288	0	144	144	288	0
Ci	140	142	282	2	143	144	287	1
Le	4	5	9	1	45	58	103	13
Ob	143	144	287	1	144	143	287	−1
Se	12	14	26	2	48	56	104	8
No	28.5	34.5	63	6	96	102	198	6
Total	750.5	781.5		31	1160	1220		60
σm_d				.97				1.60
t				2.8				3.41
p				$<.05$				$<.01$

size, and material of construction seemed related to confusion of the subjects. These results are reported in detail elsewhere (20).

Evidence of greater difficulty in accurate responding to stimuli appearing toward the right in the patterns of objects presented could not be ignored. Inadequate control of this variable and unavailability of accurate estimates of right hemianopsia prevent conclusive statements regarding the possible role of this factor. Consistency with Bucklew's (1) emphasis upon the importance of the presence of the referred-to object in speech understanding is suggested.

Apparently, there is a relationship between the effectiveness of the experimental variable and extent of language disability. Combining correct responses for the control and experimental situations gives some measure of performance level. Inspection of Table IV immediately suggests a curvilinear relationship between extent of disability and difference score (effectiveness of the experimental variable) for Procedure A. Computation of *eta* did not appear appropriate. The data for Procedure B (Understanding) where the task was easier and no zero scores resulted provided a Pearson r of $-.90$ (significant at the 1% level, N of 11, df 9). It was concluded that the effectiveness of the experimental condition increased with task difficulty until satisfactory performance became infrequent in both the experimental and control situations.

There was a non-significant *rho* of $+.26$ between the frequencies of correct naming responses to the various objects (Procedure A) and the frequencies of correct pointing to the same objects (Procedure B). Comparing by subjects the total correct frequencies for speaking with those for understanding produced

an r of $+.89$, significant at the 1% level of confidence, *df* 9. Thus overall proficiency in the two types of language behavior was related, but subjects experienced different degrees of difficulty with individual stimuli in the two situations.

IV. GENERAL DISCUSSION

Consequent to the theoretical bases of this research and its findings certain suggestions may be offered regarding the nature of aphasia, and problems of classification, testing, and treatment.

Aphasia, like other psychopathological reactions, involves an inadequacy of psychological adjustment. Behaviors may be absent, undesirable, fail to accomplish the intent of the individual, or may not coincide with the anticipation of others. The specific conditions which may contribute to language dysfunction are numerous. They may relate to structural limitations making the organization of a response impossible, to structural or developmental factors interfering with the contacting of person spoken to or object spoken about, situational variables, or personality changes.

Goldstein (6, 7) has described personality factors associated with brain damage. He speaks of the "catastrophic" effect of the injury which participates not only in the determination of the language behavior but also in the way a patient pursues life in general, how he orders his personal belongings, for example. His descriptions of the shift from "abstract" to "concrete" performances provide numerous instances of non-linguistic behaviors altered by the new life conditions of the patients. Examples of these changes were evident in the present group of subjects. Probably Goldstein would regard the experimental situation as more "concrete" hence accounting for the greater ease of responding. Some of the errors ("coffee" for cup, "water" for glass and so forth) suggest concreteness. Upon completing Procedure B, a subject was asked, "Show me the window". He looked about the table where he had been selecting the other objects requested. Perhaps this represents "inability to shift". Werner (19) and German authors whose work he reviews, speak of developmental factors in the acquisition and reacquisition of language behavior in normals and aphasics. This "microgenesis," he finds, explains peculiar associations in aphasic performance. Weisenburg and McBride (17) also noted deficiencies in non-language test results. Marie (8) spoke of general intellective disturbances. These and many similar observations suggest that we are dealing with a differently behaving organism in general not just a differently speaking individual. Other suggestions of general behavior changes in the present group of subjects were withdrawal, "emotional lability" and general apprehensiveness. That some of these may be consequent to the speech difficulty is possible, of course.

There is too, perhaps, a generalized lowering of organismic efficiency related to the injury. Structure is different; different parts, neuromuscular units, may now participate in a response. A new internal milieu, new patterns of internal stimulation, may result, making any response unit occur in an entirely different situation. (It may be conjectured that this is all that happens in lobotomy—

disruption of patterns of continual self-stimulation. The number of surgical techniques with very similar results suggests nothing more specific.)

That the incidence of aphasic patients with left rather than right hemisphere lesions is greater would also support such attitudes. We might expect that if the left hemisphere is a more active participant in behavior that injury would here produce a higher incidence of subsequent pathology. That there is not a constant relationship between specific area affected and specific speech behavior or class of behaviors suffering is demonstrated by: the inconstancy of performance of subjects in this investigation; the many spontaneous recoveries; the lack of disorder in cases where similar lesions have been demonstrated; the facilitation of speech recovery with the complete removal of damaged lobes; the existence of aphasic behaviors without demonstrated neural damage. These latter range from the relatively infrequent troubles of everyone to hypnotically induced aphasic performances (4) and the "hysterical aphasia" as reported by di Lalli (17, p. 34).

The problem of diagnostic labels or classification has been a difficult one. Disputes have ranged from the descriptiveness of a particular term to whether or not "pure" types exist. Some writers like Nielsen (14) tend toward greater specificity of nomenclature noting, for example, the differences among individuals who are unable to read. However, the principal differentiation between many of his alexias is on the basis of brain area thought to have been damaged. On the other hand, we have the very broad classificatory system of *predominantly* expressive, receptive, amnesic, or expressive-receptive disorders (17). The cases included in the present study would not seem to fit any rigid classificatory system. Each was quite different although some characteristics were common to one or more subjects.

When should an individual be labeled alexic or agraphic? Experience indicates he may write at one time and not another, or he may write one sort of material and not another, and so forth. We can establish arbitrary standards and define agraphia in terms of whether or not the patient wrote according to specific instructions during examination. This would be convenient but not descriptive of a man's specific writing difficulties. A concrete illustration of the problems encountered was demonstrated by a patient during pre-experimental studies. A list of six words on one page and pictures of the corresponding six objects on another page were used (18). The subject was asked to read from the printed card. He failed. He was then asked to read a single word and select the appropriate object from the series of pictures. He again failed for all six. Following this the experimenter first pointed to one of the pictures and instructed the patient to locate the correct word among the six. Here there was complete accuracy. Was he alexic or not?

Beyond very general classifications, diagnosis of difficulties of aphasic patients appears to demand extremely individualistic treatment. One might proceed from the descriptions of normal language behavior afforded by some system such as that offered by Kantor (10, 11) noting the difficulties in referee versus referor action, the distinctions between difficulties in the morphology or the adjustment

of the response, the difference between linguistic and non-linguistic verbal action, problems relating to the participation of the auxiliary or adjustment stimulus, setting and historical factors. Beginning with behavioral analysis, pathology would involve lack, inappropriate ("wrong"), or distorted linguistic response. Further distinctions can be made on etiological bases—developmental lacks, including structural limitations, stimulational deprivation, interference after language has developed as the result of the organism's truncation or psychological trauma. Behaviors fitting the above descriptions exist where cerebral pathology does not exist (or has not been demonstrated). Such analyses in addition to labeling in terms of whether or not the patient reads (vocalizes) particular words and what brain areas are suspected to be involved would not only be more descriptive but would be more useful in any reeducative program.

Implied by the above and the results of this experiment is a reevaluation of the procedures of clinical testing. These, today, not only in relation to aphasia, are constructed primarily on the basis of a philosophy of response equivalence. Successes in terms of providing the form of the response required by the examiner do not involve equivalent behaviors. Comparably, failures are not equivalent as revealed, for example, in the analysis of errors in another part of this study (20). On the other hand, adjustmental equivalence may be approximated when the response is different.

Treatment could be adapted to such findings. In the first place, all the behaviors that show a defective test rating are not "lost" with the tissue destruction. Most reeducational procedures do not consider this and retraining becomes a process of reestablishing the connection between object and word, printed symbol and object, printed symbol and spoken word, and so forth. The patient learns to read words presented on cards and to name objects as the teacher points to them. In a sense this is entirely new learning for the aphasic. It also involves adjustments which would be new to the teacher were the table turned.

Settings which would facilitate the elicitation of speech behavior could be contrived rather than assuming loss and necessary reeducation. We might approximate "true" linguistic situations and perhaps find greater transfer to everyday stimulational conditions. Drilling the individual to vocalize "fork" when he has demonstrated the inability to name the object in ordinary testing might be altogether unnecessary. In the case of subjects in this experiment "fork" may have been repeated upon instruction although it was impossible to obtain the response in a naming situation. Furthermore, it was noted that when one was asked, "Show me the fork", he kept repeating to himself, "fork . . fork . . fork" although he pointed to the knife. It would seem that he is capable of executing the form of this response, that drill upon lip and tongue position for this vocalization may be unnecessary, even unwise. His difficulty is more adjustmental than morphological. By contrast another patient adequately adjusts with "ork" or some even less recognizable vocalization. Here the difficulty might be described as relating more to the morphology of the response. These suggestions are directed toward an analysis of the kinds of difficulty involved. It would not be a simple description in terms of whether or not he writes, speaks, or reads. Exploration of specific variables such as the contribution of hemianopsic or

other visual defects, auditory limitations, difficulties in attending, and so forth, might first direct our attention to non-linguistic retraining.

It is possible that the methods with which this approach is contrasted are not only not sufficiently positive in their efficacy as retraining devices but that the failures associated with this "new" learning and its childishness may have negative influences upon the retraining.

Opportunity was afforded to test some of these suggestions with one of the patients in the group and results appeared to be of a positive nature. There were two aspects of therapeutic work. First offered were suggestions which would facilitate relaxation because of the tension that appeared to develop in speech situations. And, then, most of the time was spent in conversing, and his responding to, "Well, what have you been doing today?" or more specific questions deriving from what had been said. The foregoing suggests a "personality" element in the aphasic's language difficulties which has been insufficiently stressed.

In the case of the aphasic with biological limitations, perhaps maximal immediately following injury, adequate organization of responses may be impossible. What were simple situations to which to respond are now difficult ones. Studies of non-aphasic behavior problems where the response was made impossible by stimulus complications may be considered. The persistence of behavioral disorganization following too difficult discriminations was probably first reported for Pavlov's dogs (16). Hill (9) found behavioral breakdown when human subjects were confronted with situations for which no adequate response had been established. Furthermore speech responses were slower to recover than other movements. The persistence, or learning, of such effects suggests possible prophylactic procedures in relation to the newly brain-injured. No physician or relative would encourage the paralyzed patient to get out of bed immediately and walk until some degree of recovery had been accomplished. Speech, on the other hand, is assumed to require so little "effort" that it is immediately attempted. Failures probably lead to redoubled efforts to obtain speech even while the organism remains in a marked state of lowered efficiency. We can only guess at this point about its effect upon later linguistic behavior. But it is conceivable without demands for speech, perhaps even to the point of sedation until a higher level of recovery is accomplished, that the later disorganization of speech behavior might be minimized. Recently, some promising attempts to control speech stimulation during the recovery period of the brain-damaged patient have been reported by Milisen (13).

V. SUMMARY

The effect of stimulus variables upon language behavior of aphasics was studied in two different speech modalities, naming and understanding. In the first (Procedure A) subjects were asked, "What is that?" as the experimenter pointed to a series of twelve objects in a predetermined order. In the second (Procedure B) the subject was required to select one of the objects as he was directed to, "Show me the ————".

For each of these behavior classes the responses of eleven aphasic subjects

were compared in a control and experimental situation. In the former a group of twelve common table objects was presented in a constant but unfamiliar setting. In the latter the objects appeared in a conventional table setting Control and experimental presentations followed the usual CEEC or ECCE orderings, each sitting, for six such sessions. Thus the series of twelve stimuli were presented a total of twelve times with both the control and the experimental settings of objects.

1. Subjects named objects (Procedure A) correctly when they were presented in context more frequently than when they were not. The difference was significant at less than a 5% level of confidence. Taken separately, ten of the twelve objects were named correctly more often in context. Only one of these differences (spoon) was significant at less than a 5% level of confidence. Eight of the eleven subjects responded more frequently to the objects in context. Three showed no difference. Two of these had zero scores in both the control and experimental situations; the third had maximum scores in both situations. Confirmation of the experimental hypothesis that stimuli presented in context favor response elicitation was concluded.

2. Subjects pointed to objects (Procedure B, Understanding) correctly more frequently when they were presented in context than when not. The difference was significant at less than a 1% level of confidence. Taken separately, nine of the twelve objects were named correctly more often in context. Only one of these differences (glass) was significant at less than a 5% level of confidence. Nine of the eleven subjects responded correctly more frequently to the objects in context. The score of one subject was higher in the control procedure. One showed no difference with maximum scores in both the experimental and control situations. It was concluded that the foregoing was consistent with the experimental hypothesis.

3. It was concluded that the effectiveness of the experimental condition upon language behavior increased with task difficulty until satisfactory performance became infrequent in both the experimental and control situations. A curvilinear relationship existed for Procedure A. For Procedure B a Pearson r of $-.90$, significant at the one per cent level, was obtained.

4. Also mentioned are other tentative findings from this admittedly exporatory study. And in accord with that sort of intention it has raised perhaps more questions than it has answered. Furthermore, studies with other subjects and with other materials need to be performed to substantiate the bases used for the hypotheses regarding the nature of aphasic phenomena and their diagnosis and treatment.

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STIMULUS VARIABLES IN APHASIA: II. STIMULUS OBJECTS

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I. INTRODUCTION

In an earlier report (11) evidence was presented to support the thesis that stimulus variables determine the presence or absence of speech behavior in the aphasic. This emphasis on stimulus conditions was offered in contrast to the viewpoints which primarily correlate aphasic phenomena with the lesional status of the patient. Specifically the finding was that the context in which a stimulus object was presented to the subject might facilitate correct responding. Variables in addition to brain damage, such as the behavioral history of the patient, other setting factors, and differences in stimuli also may determine the responding of the aphasic.

The present report, based on data obtained in the above-mentioned study, reviews the importance of the latter variable—differential responding to various stimulus objects. Two problems were investigated: 1. Does the subject respond correctly more frequently to some objects than to others? 2. When the subject fails to respond correctly are the errors of a random sort? Exploration of these issues was conducted in two language modalities, speaking and the understanding of speech.

II. PROCEDURE

Description of the eleven aphasic subjects and the details of the experimental procedure were presented elsewhere (11). Two experiments were conducted. One involved speaking or the naming of objects to which the experimenter pointed (Procedure A, Speaking). In the second, the subject was instructed to select the object named by the experimenter (Procedure B, Understanding). The materials consisted of twelve table objects (knife, salt shaker, napkin, fork, pepper shaker, sugar bowl, saucer, glass, cream pitcher, spoon, cup, plate) presented under two conditions: in two rows of six objects each (control situation) and in a conventional table setting (experimental situation).

Decisions regarding scoring may be considered arbitrary and the results must be interpreted in terms of the procedure followed. "Knife", "fork", "spoon", "napkin", "cup", "saucer", "plate", were the only responses given for the corresponding objects which were scored as correct. Because of their frequency of occurence for different subjects and speech convention as interpreted by the experimenter, alternative responses were allowed for some of the objects. "Salt" or "salt shaker" and "pepper" or "pepper shaker", "sugar" for sugar bowl, "milk", "cream", "creamer" or "pitcher" for cream pitcher, "tumbler" or "glass" for glass, were allowed. Thus, in some cases credit was given when the actual content or usual content was named rather than the table object *per se*. In other instances

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where the usual content was named—"water" for glass—a failure was scored. The following criteria were considered: 1. The responses accepted were ones offered frequently by the subjects; 2. They corresponded to the expected performance of normal speakers; 3. The other responses not allowed were infrequently given even by the same subject at different times and usually after what was judged to be difficulty in responding.

Spontaneous corrections within the alloted time were permitted. If for the knife the subject responded "fork" then "knife", but within the time limits, the response was correct. If, on the other hand, the reverse was true, or the correction did not occur within the time limit, it was scored a failure.

Evaluations in terms of adjustmental adequacy were made in judging responses with articulatory errors. Response morphology was ignored except where it was so distorted that the experimenter could not recognize the behavior. This, of course, permitted some possible error. But in most instances the decision was not a difficult one. Thus "oon" and "poon" were considered satisfactory for spoon or "ife" for knife, and so forth.

Responses scored as failures were classified into two main categories—*analyzable* and *unanalyzable* errors. The former included any response scored a failure but which would have been correct for another object in the experimental series (for example, "spoon" for cup) and which the subject apparently accepted. *Unanalyzable* errors included no verbalization, unrecognizable sounds, responses which could not be classified analyzable as described above, profanity, and rejected responses which were not corrected. Thus "fork—no" for knife was an error using a response which would have been classified as analyzable except for the subject's rejection. The same scoring and classification would have been followed if the subject rejected the correct response as "knife—no". In some instances there was marked perseveration. These responses were treated in the same manner as described above but for certain purposes in the presentation of results they would be more appropriately excluded from the analyzable material. For some comparisons the data were examined using both methods of classification.

For Procedure B, scoring problems were simplified. Responses involved either pointing to the objects on the table or lifting them. The subjects restricted themselves to twelve possibilities as opposed to the unlimited number of responses which could be made in the speaking or naming situation. In fact, in only six out of nearly three thousand of these responses did a subject fail to select some object in the series. The only difficulty in scoring here was when vacillation was displayed. A subject would alternate fork-knife-fork-knife-fork or might point to several different objects. Regardless of the preceding behaviors involved, the final choice was the one scored.

III. RESULTS AND DISCUSSION

Consistent with the statement of the problems our analysis followed two courses: 1. Are correct responses more frequent to some stimulus objects? 2. Are errors random or do they conform to some pattern?

For these purposes the data from the control and experimental situations of the basic study were combined. Thus we are concerned only with differential responding to the objects. It was impossible to complete all sessions for one subject and his results were pro-rated multiplying by 1.5. This accounts for the half values in the tables.

Tables IV and VI describing both correct and error responses show the totals for each object in the speaking and understanding procedures, respectively. Utilizing analysis of variance an F value (between objects) of 1.81 ($p > .05$ for 11 and 110 df) was obtained for the data of Procedure A (Speaking), and an F value (between objects) of 4.45 ($p < .01$ for 11 and 110 for df) for Procedure B (Understanding). Tables I and II provide summaries of the analyses of vari-

TABLE I

Analysis of Variance Summary of Correct Response Frequencies for Procedure A (Naming)

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Objects	11	201	18.3	1.81*
Between Individuals	10	14189	1418.9	
Error (Interaction)	110	1112	10.1	
Total	131	15502		

* $p = > .05$ for 11 and 110 *df*.

TABLE II

Analysis of Variance Summary of Correct Response Frequencies for Procedure B (Understanding)

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Objects	11	583	53	4.45*
Between Individuals	10	4729	472.9	
Error (Interaction)	110	1306	11.9	
Total	131	6618		

* $p = < .01$ for 11 and 110 *df*.

ance as applied to the correct response frequencies for each object in the two procedures.

The significant F in the case of Procedure B indicates there are real differences in the correct response frequencies to the different objects (2). The standard error of the general mean was obtained by employing the error variance, and t's were obtained utilizing this standard error of the mean and the differences between the general mean and the individual object means (3). Table III presents a summary of these results for Procedure B. It may be seen that the mean response frequency for napkin was greater than the general mean by a difference significant at the 1% level of confidence. In similar manner cup and saucer produced responses significantly less than the general mean at the 5% level of confidence.

Various hypotheses could be offered to account for these results, none of which could be confirmed from the present data. Characteristics of the stimuli which might relate to aphasic language behavior will be discussed at several points both in relation to correct and error responses. Familiarity with the object, ease of speaking and positions of the objects in the two settings are some of the possibilities. One particular suggestion may be offered in relation to the greater frequency for napkin. In a sense this may be considered a non-paired object by contrast with cup and saucer and knife and fork. Not only were there fewer errors recorded for napkin, but it appeared that response time and confusion in selection were minimized. For other choices the subject would vacillate, first pointing to one and then another of the objects in the "pairs." Furthermore, there was a selectivity of errors by the subjects. In the case of napkin it will be

shown in a later section that there were no error choices demonstrated to occur with greater than chance frequency. For most of the subjects the response to plate (perhaps also less paired) could be described in almost identical manner. The greater randomness in responding of some subjects tends to obscure this distinction in the total results as presented. On the other hand, cup and saucer with the lowest frequencies may not permit the same sort of explanation in that they may be no more paired than others in the group. It could be argued, of course, that these are not only paired linguistically like the others, but that in addition they are more intimately linked in use. The fact that they appeared consistently in the right half of the settings under both the experimental and control conditions was discussed as a possible variable in another report (11).

Subjects ranked similarly in overall excellence of performance in the speaking and understanding situations. Comparing total correct response frequencies for the two situations produced a *rho* of +.89, significant at the 1% level of confidence, *df* 9. Thus individuals who had the greatest difficulty with one task also seemed to have the lower scores for the other. They did not have difficulty with the same objects in the two situations, however. A non-significant *rho* of +.26 was obtained between the correct response frequencies to the objects in the two procedures.

A further correlational comparison was made between the frequencies of responses used correctly with the frequency for erroneous usage (for example, "knife" for knife versus the total of "knife" responses to the other eleven objects). For Procedure A the *rho* was +.40 and for B the *rho* was −.40. Neither was statistically significant but the opposing direction of the relationships suggests hypotheses for further investigation. In the speaking situation responses given correctly were perhaps "easier" and were also given incorrectly to stimuli for which the appropriate language response was difficult. In the second experiment, however, the response (understanding, discriminating the object, or pointing) which was made more frequently as a correct response was used less frequently than other responses as an error. That is, where the subject responded easily to knife he did not point to it when he could not "find" one of the other objects to which he was instructed to point; he tended to select some other stimulus in making his error.

In preliminary research with feebleminded subjects using these same procedures correct responses were again greater for some objects. In this case, however, it was hypothesized that ease and difficulty were related to familiarity. For example, knife, fork and spoon were responded to with high accuracy. Cup was an exception, being confused with the physically similar sugar bowl. Napkin had a relatively low score, and so forth (12).

It may be concluded that some evidence exists to support the hypothesis that certain stimuli were more (or less) effective in correct response elicitation.

In the analysis of errors our first interest was in the determination of greater than chance frequency in any response category. In Procedure A (Speaking) only the correct responses and what were described in the section on procedure as analyzable errors (those which would have been correct responses to other

stimuli in the experiment) were considered. In other words, some errors such as unrecognizable sounds, swearing, no verbal response, and others as described in the scoring procedure were not included in this analysis. In Procedure B (Understanding) all responses were considered inasmuch as only six of over three thousand were not analyzable. The subject (Va) in these cases "could not find" an object to which to point among those present. Because of the small number of such responses they were ignored in the statistical analysis.

Chance frequency was determined by considering only the analyzable errors. Since only eleven analyzable error responses (twelve possible objects minus the correct one) were possible, the error total was divided by eleven. A chance curve of one "hit" against ten "misses" was plotted on "Individual Standard Error" paper designed by Mostellar and Tukey and the obtained values compared with it to test the hypothesis that analyzable error responses are distributed according to chance. Frequencies are indicated in Table IV for Procedure A and Table VI for Procedure B. The plusses denote significant differences above chance expectancy ($^{+}$ and $^{++}$ at the 5% and 1% levels of confidence, respectively).

In Procedure A there was obvious perseveration of analyzable responses by two subjects. (The outstanding perseverations of other subjects were of responses which were unanalyzable.) One patient (Le) used "sugar" repeatedly and (Se) used "pepper." Table V presents an analysis of the data in Table IV after these responses, whether correct or not, of the two subjects were rescored as "unanalyzable." Hence the correct scores for sugar of subject (Le) and for pepper of (Se) were reduced to zero. It is probable that these perseverations were more like other perseverative nonsense vocalizations or other unanalyzable speech. It is not claimed that this cleared the correct or analyzable error data of perseveration. It only eliminated those responses that were unquestionably of this type.

Examination of the data reveals that all correct responses occurred with greater than chance expectancy at less than the 1% level of confidence and that errors when made were selective for the majority of objects. Table V for Procedure A (Speaking) shows "fork" and "spoon" responses were relatively frequent for knife, "pepper" for salt, "spoon" for fork, "salt" for pepper, "cream" for sugar, "sugar" and "cup" for cream, "fork" for spoon, and "saucer" for

TABLE III

Correct Response Frequency (Procedure B, Understanding) for each Object

Object	Knife	Salt	Napkin	Fork	Pepper	Sugar	Saucer	Glass	Cream	Spoon	Cup	Plate	Total
Total	203.5	209.0	250.0	196.5	205.0	185.0	163.5	211.5	192.0	189.0	159.0	216.0	2380.00
Mean	18.5	19.0	22.7	17.8	18.6	16.8	14.9	19.2	17.5	17.2	14.5	19.6	18.03
Diff.	.47	.97	4.70	−.17	.61	−1.21	−3.17	1.20	−.58	−.85	3.58	1.61	
t	.34	.69	3.35	.12	.44	.86	2.26	.89	.41	.60	2.56	1.20	
p			<.01				<.05				<.05		

Tests of the difference between the general mean and individual object means. The t was obtained thru employment of the error variance. Standard error of the mean was 1.4, df 110.

TABLE IV

Distribution of Responses to each of the twelve experimental Stimuli in Procedure A (Naming). (N of 11)

		Stimulus											An
		Kn	Sa	Na	Fo	Pe	SB	Sr	Gl	CP	Sp	Cu	Pl	
Responses	Kn..	125	1	0	2	0	0	0	0	0	1.5	0	0	4.5
	Sa...	0	126	0	0	12^{++}	0	0	0	0	0	0	1	13.0
	Na..	0	0	131	0	0	0	0	0	0	0	0	0	0.0
	Fo...	19^{++}	1.5	0	149	0	0	1	0	0	4	1	1.5	28.0
	Pe...	15^{++}	25^{++}	10^{++}	17^{++}	148	8^{++}	10^{++}	8^{++}	13^{++}	15^{++}	15^{++}	15^{++}	151.0
	SB..	0	8^{+}	0	3	7^{++}	135	4	5^{+}	12^{++}	6	2	0	47.0
	Sr...	0	0	0	0	0	0	110	0	0	0	3	0	3.0
	Gl...	0	0	0	0	0	0	1	117.5	0	0	0	0	1.0
	CP..	0	0	0	0	0	6^{++}	1	0	107	0	0	0	7.0
	Sp...	6.5	0	0	2.5	0	0	1	0	1.5	143.5	0	1	12.5
	Cu...	0	0	0	0	0	1	0	1	4	0	117	0	6.0
	Pl...	0	0	0	0	0	0	0	0	0	0	0	123	0.0
Totals	Co...	125.0	126.0	131	149.0	148	135	110	117.5	107.0	143.5	117	123.0	1532
	An...	40.5	35.5	10	24.5	19	15	18	14.0	30.5	26.5	21	18.5	273
	Un..	98.5	102.5	123	90.5	97	114	136	132.5	126.5	94.0	126	122.5	1363
		264	264	264	264	264	264	264	264	264	264	264	264	3168

Indicated are the error response frequencies significantly greater than chance expectancy (1 to 11); ++, above chance at the 1% level; +, above chance at the 5% level. Kn, knife; Sa, salt; Na, napkin; Fo, fork; Pe, pepper; SB, sugar bowl; Sr, saucer; Gl, glass; CP, cream pitcher; Sp, spoon; Cu, cup; Pl, plate; Co, total correct; An, total analyzed errors; Un, total unanalyzed errors.

cup. On the other hand for several objects (saucer, napkin, glass, and plate) there were no errors given with a significant consistency when perseverative responses were excluded (compare Tables IV and V). Similar errors were made in the part of this study dealing with the understanding of speech (Table VI). Here, too, it may be concluded that errors were not of a random nature. As in Procedure A there were stimuli for which there were no consistently chosen errors (napkin and plate). Other objects had one or more kinds of error responses given with a frequency significantly greater than chance: "fork" for knife; "pepper" for salt; "knife" for fork; "salt" for pepper; "saucer" and "cream" for sugar; "sugar," "cream" and "cup" for saucer; "cup" for glass; "sugar" for cream; "knife" and "fork" for spoon; "sugar", "cream" and "saucer" for cup. On the other hand some responses were used infrequently as errors. This may be seen by reading the tables horizontally. For example, the "napkin" response was never used erroneously in the speaking situation and only three times in the understanding phase of the study. Although the analysis was not made here this and other response categories were employed less than expected on a chance basis.

The variables determining selection of the error response cannot be clearly

TABLE V

Distribution of Responses to each of the twelve experimental Stimuli in Procedure A (Naming). (N of 11)

		Stimulus											An
		Kn	Sa	Na	Fo	Pe	SB	Sr	Gl	CP	Sp	Cu	Pl	
Responses	Kn	125	1	0	2	0	0	0	0	0	1.5	0	0	4.5
	Sa	0	126	0	0	12^{++}	0	0	0	0	0	0	1	13
	Na	0	0	131	0	0	0	0	0	0	0	0	0	0
	Fo	19^{++}	1.5	0	149	0	0	1	0	0	4^{+}	1	1.5	28
	Pe	0	5^{++}	0	0	126	0	0	0	0	0	0	0	5
	SB	0	0	0	0	0	126	1	0	5^{++}	3	1	0	10
	Sr	0	0	0	0	0	0	110	0	0	0	3^{+}	0	3
	Gl	0	0	0	0	0	0	1	117.5	0	0	0	0	1
	CP	0	0	0	0	0	6^{++}	1	0	107	0	0	0	7
	Sp	6.5^{+}	0	0	2.5^{+}	0	0	1	0	1.5	143.5	0	1	12.5
	Cu	0	0	0	0	0	1	0	1	4^{+}	0	117	0	6
	Pl	0	0	0	0	0	0	0	0	0	0	0	123	0
Totals	Co	125	126	131	149	126	126	110	117.5	107	143.5	117	123	1501
	An	25.5	7.5	0	4.5	12	7	5	1	10.5	8.5	5	3.5	90
	Un	113.5	130.5	133	110.5	126	131	149	145.5	146.5	112	142	137.5	1577
		264	264	264	264	264	264	264	264	264	264	264	264	3168

Same as Table IV except perseverative responses of two subjects are classified as unanalyzed. Indicated are the error response frequencies significantly greater than chance expectancy (1 to 11); $^{++}$, above chance at the 1% level; $^{+}$, above chance at the 5% level. Kn, knife; Sa, salt; Na, napkin; Fo, fork; Pe, pepper; SB, sugar bowl; Sr, saucer; Gl, glass; CP, cream pitcher; Sp, spoon; Cu, cup; Pl, plate; Co, total correct; An, total analyzed errors; Un, total unanalyzed errors.

decided on the basis of this investigation. Various possibilities present themselves. Many errors seem primarily to be responses which would have been appropriate to a related object. Perhaps in the development of stimulus-response coordinations an object may become endowed with various related stimulus functions or values. With the lowered efficiency of the organism other than the most appropriate one may operate. Some may wish to interpret this as a "regression" to behavior of an earlier stage of language acquisition. To the child learning to speak, the fork at first may have the stimulus value of "spoon". Further training fixes a more discriminative response. Thus the phenomena appear similar to those discussed in the literature as stimulus generalization and differentiation. Interesting also are the stages of language development and recovery referred to by Werner (10) and the German authors whose work he reviews. This unfolding he calls "microgenesis" and he compares the behavior of aphasics with the performance of normals to tachistoscopically presented stimuli. He further illustrates his various "spheres of meaning" from the case reports of Wepman (9) and Weisenburg and McBride (8).

The relatedness of stimulus value could be derived in various ways. There is

TABLE VI

Distribution of Responses to each of the twelve experimental Stimuli in Procedure B (Understanding). (N of 11)

		Stimulus												An
		Kn	Sa	Na	Fo	Pe	SB	Sr	Gl	CP	Sp	Cu	Pl	
Responses	Kn...	203.5	3	4	34.5^{++}	2	4	4	4	2	18^{++}	7	3	85.5
	Sa....	7	209	0	4	51^{++}	8	10	3	2	6	2	2	95.0
	Na...	0	0	250	1	0	0	0	0	0	0	0	2	3.0
	Fo....	27.5^{++}	1	2	196.5	1	0	8	5	0	19.5^{++}	11	8	83.0
	Pe....	1	37^{++}	1	8	205	3	2	1	2	0	2	1	58.0
	SB...	7	1	2	3	1	186	23^{++}	5	37.5^{++}	8	18^{++}	8.5	114.0
	Sr....	3	6	0	1	0	14.5^{+}	163.5	3	9	5	20^{++}	8.5	70.0
	Gl....	3	1	1	1	1	2.5	3	211.5	7	3.5	9	4	36.0
	CP...	3	3	1	5	0	34^{++}	20.5^{++}	7.5	192	4	22.5^{++}	6	106.5
	Sp....	4	3	0	5	3	1	2	2	4.5	189	4	1	29.5
	Cu...	1	0	1	1	0	5.5	18.5^{++}	15^{++}	5	7	160	4	58.0
	Pl....	3	0	1	2	0	5.5	8.5	7	3	4	7.5	216	41.5
Totals	Co....	203.5	209	250	196.5	205	186	163.5	211.5	192	189	160	216	2382
	An...	59.5	55	13	65.5	59	78	99.5	52.5	72	75	103	48	780
	NR..	1.0	0	1	2.0	0	0	1.0	0.0	0	0	1	0	6
		264	264	264	264	264	264	264	264	264	264	264	264	3168

Indicated are the error response frequencies significantly greater than chance expectancy (1 to 11); $^{++}$, above chance at the 1% level; $^{+}$, above chance at the 5% level. Kn, knife; Sa, salt; Na, napkin; Fo, fork; Pe, pepper; SB, sugar bowl; Sr, saucer; Gl, glass; CP, cream pitcher; Sp, spoon; Cu, cup; Pl, plate; Co, total correct; An, total analyzed errors; NR, no response, unable to find object.

a similarity in use of the pairings. In ordinary speech the objects are frequently referred to in groups—"knife, fork, and spoon," "cup and saucer", "salt and pepper," and so forth. In some instances there is a similarity in appearance, form, color, size or material of construction. In this connection Table VI (Understanding) shows relatively greater ease in responding to napkin (only 14 errors among 264 responses) which immediately suggests that the absence of an object commonly paired with it (or its being made of a material different from all other objects) may have facilitated correct performance. The same was true for plate among most of the subjects although one subject (Wh) made what appeared to be completely random responses. This, of course, lowered the total correct frequency. Here, as with napkin, no error response category included a frequency demonstrated to be significantly greater than chance. For Procedure A in addition to these two objects, saucer and glass produced no consistency in errors.

It could be argued that the knife response to fork is a function of the presence of knife among the stimuli immediately available to the subject. An evaluation of this alternative could come with a naming procedure where only one object was presented at a time. (Exploratory testing of this possibility was attempted with one subject following completion of the experimental procedure. Errors were of the same kind.)

Free association responses to the various words or objects may reveal relationships similar to those obtained here. The Kent-Rosanoff free association

tables (6) were examined for a tentative answer. Only one word in their series corresponded to one used in this experiment. It was salt; and the most frequently associated word was pepper, given 142 times to 1000 stimulations. This could be considered to relate to the error findings in which pepper was a frequent choice for salt in both procedures; however, of the next most frequent responses sugar (88), taste (87), food (46) and bitter (40) only sugar was given at any time by the aphasics. It was the response to salt of the subject who perseverated the word sugar for many of the objects in Procedure A. In Procedure B it was pointed to only once upon the instruction, "Show me the salt". Even if correlations between normal free associations and the aphasic errors were established, we would still need to describe the psychological basis for the associations.

From observing aphasic behavior other variables, which for specific cases may determine error responses, were suggested. These, however, did not appear in the statistical analyses and could not be evaluated from the present experimental data. Offered as suggestions they could be the basis of investigative procedures designed for their clarification.

Already mentioned was perseveration which was obvious in the responding of two subjects. Occasionally it appeared to be present for other subjects, but not to the same extent. In the case of Procedure B (Understanding) it was possible that errors may have been related to inadequate perception of the auxiliary stimulus (speech of the experimenter). Thus confusions might appear between saucer and salt or knife and napkin. These related only to first sounds but other characteristics might also be considered.

On a few occasions the following sort of phenomenon was observed. Presented with the first stimulus the subject would err. For the next stimulus an error also would be recorded but the response was the one which would have been correct for the first stimulus. According to Skinner (7) such verbal behavior might have been interpreted in terms of the summating effect of a second stimulus (not necessarily a linguistic one) which would bring the response over threshold. A previous failure might influence a subsequent response in another way. Having incorrectly employed "cream pitcher" as a response, the subject upon being confronted with this object may be led to another incorrect response because of having used already the one which would now be most adequate. Or, when a subject for some reason is unable to organize the response "salt" does he speak pepper "deliberately," when he is able, as the closest approximation? This would be similar to the frequently observed distortions of the stutterer engaging in circumlocution when he anticipates blockage of speech. However, in this connection self-criticism of some subjects in rejecting responses also should be mentioned. They would respond to salt with "pepper, no" or even "salt, no".

Other errors, particularly in Procedure B, may have been conditioned by position habits. For example, the selection of an object may have been facilitated because of its approximate placement where the correct article was in the preceding setting. This suggestion was supported by various observations. Subjects in the control situation of Procedure B seemed to first direct their glance to the lower left quadrant of the table for "fork." The knife in the control arrangement was in this position.

Still another type of variable which might be considered in the selectivity of error responses would be that of special biological limitations (ease in forming certain sounds, auditory and visual defects). One in particular, hemianopsia, suggested itself during the course of this investigation. Although experimental control was inadequate there was some evidence of greater difficulty in responding to objects in the right of the field of vision. It was possible that speech references of the experimenter to objects in the hemianopsic area were not as accurately perceived as others. This would be consistent with Bucklew's (1) finding with normals that understanding of language was affected by the presence or absence of the referred-to object.

There were other observations for one or more individuals such as the following: Subjects would frequently repeat correctly the name of the object mentioned in the instruction and then point to another. Responses of "coffee" for cup or "water" for glass although scored as errors also demonstrate the lack of complete randomness when failures occur. The quantitative data were derived solely from the final response selections of the subjects, but the vacillations in naming, pointing, or even eye movements, as observed, were recorded. These data were not sufficiently accurate to warrant quantitative treatment. Even when the final response was correct the impression was obtained that the preceding confusion was of the same nature as previously outlined.

Despite the appearance of consistency in the combined data this did not represent truly the performance of all subjects for all stimuli. In the understanding procedure, (Gl) selected a "related" object without exception when he made an error. Other subjects may have approached a chance distribution of errors for some stimuli. Mentioned previously was the observation of relatively few errors (Procedure B) for plate. However, one subject (Wh) responded correctly only twice and demonstrated what appeared to be complete randomization of errors for this object. What may be observed as differences between subjects also appeared for the same subject within a few minutes.

In this study no analysis was made of the unanalyzable errors, some of which appeared to be nonsense responses—often perseverating. Examples were "matter-matter" or "eye-eye" of (He). It should be noted, however, that at least some of these were offered with what appeared to be conviction and finality. The subject carefully examined the object, pointed, spoke, and relaxed as if waiting for the next stimulation.

That factors other than brain damage *per se* contribute to our understanding of the behavior of the aphasic seems established. No more should the patient's behavior be regarded as fixed by tissue destruction. He varies from time to time, responds with greater facility to some objects than to others and differently to the same object in different situations.

In addition we find that when the subject does not respond with the action required by a test he may behave in a related manner. The use of dichotomous success or failure test scoring does not appear adequate for understanding these phenomena although it may be significant for making gross predictions of future aphasic performance. Parallel uses and criticisms may be made for scoring problems in other research (5). To say "fork" when asked to name the object

—knife—is not of the same significance as speaking "door" or swearing or not vocalizing at all. This study of errors also suggests that once-learned behavior was not always completely lost with damage to brain tissue thought to subserve such performance. Rather than retraining to replace "lost" word behavior, procedures to elicit appropriate responses of which the individual is still capable may be possible. These might include indirect techniques to facilitate attention and discrimination. Those who have worked with aphasic patients recognize individual differences and suggest varied remedial approaches (4, 9, 11).

IV. SUMMARY

The linguistic behavior of aphasics in relation to stimuli was examined in two modalities, speaking and understanding.

1. It was found that aphasic subjects were able to name, or on instruction to point correctly to, some objects with greater frequency than to others.
2. It was found that aphasic subjects when making a linguistic error did not give a random response, but often one related along some dimension to the appropriate one.
3. Discussion of these results and possible implications for practical work with aphasics were offered.

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SPONTANEOUS RECOVERY FOLLOWING RESPONSE DECREMENT TO THE MÜLLER-LYER ILLUSION[1]

PAUL T. MOUNTJOY[2]

Köhler and Fishback (7, 8) have recently reported data which they interpreted as indicating that spaced trials had a relative advantage over massed trials in terms of producing more rapid rates of response decrement to the Müller-Lyer illusion figure. They stated: "It seems indeed that . . . the size of the illusion appears to drop overnight." Three earlier studies (5, 6, 9) were cited as having previously reported such findings; but re-examination of these studies by the present author (10) did not appear to substantiate the interpretation of Köhler and Fishback. None of the published studies have met modern criteria of experimental design or statistical control. It appeared desirable to conduct a more carefully controlled investigation to determine what relationship might be found between intertrial interval and the reported decrement to the Müller-Lyer illusion figure.

Since the "destruction" of the Müller-Lyer illusion consists operationally of repeated elicitations of a response which is already present in the organism's repertoire (and a consequent decrement in that response) it may be regarded as analogous to laboratory studies of habituatory decrement (3). Consideration of this analogy led to three predictions which should be verified if the response decrements to the illusion figure do consist of habituatory decrements. These are: (a) More rapid rates of response decrement occur with massed than spaced trials (1, 3, 4, 11). (b) More rapid rates of response decrement occur with longer exposure times per trial than shorter exposure times per trial (1, 12). (c) Spontaneous recovery of the illusion occurs during the passage of time between experimental sessions (3, 11). Testing these predictions may indicate the relative tenability of the habituation hypothesis and Köhler and Fishback's figural aftereffects interpretation.

PROCEDURE

Apparatus

A line drawing of the apparatus is shown in Fig. 1. The Brentano figure (modified by the omission of the horizontal line connecting the three arrowheads) was etched on two sheets of clear lucite. On the standard stimulus the points of the two arrowheads were 153 mm apart. Each arrowhead consisted of two lines,

[1] This paper summarizes a thesis submitted to the Faculty of the Graduate School of Indiana University in partial fulfillment of the requirements for the degree of Master of Arts. The author wishes to express his appreciation to Drs. J. R. Kantor, R. N. Berry, W. K. Estes, and C. J. Burke for their assistance in the conduct of this research.

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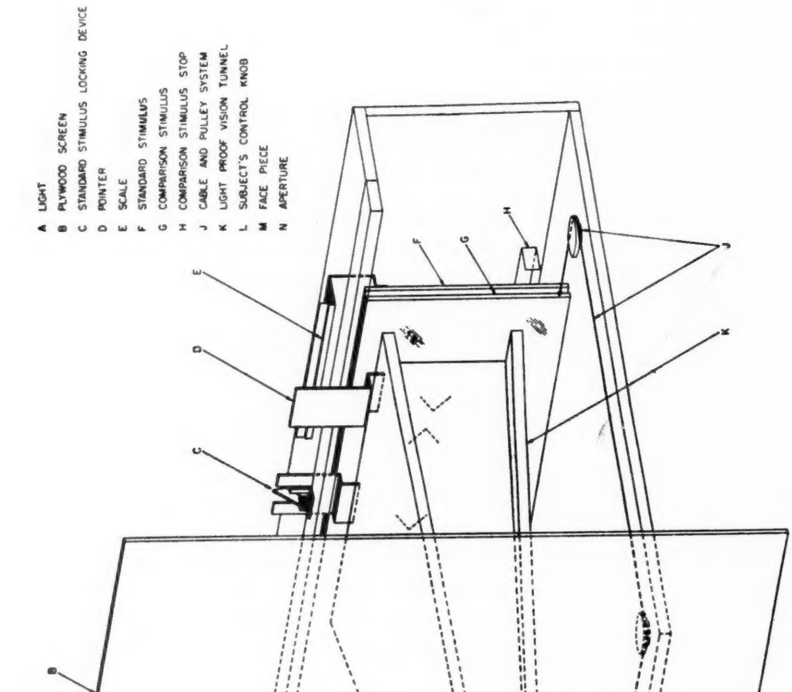

FIG. 1. Apparatus used to present the illusion figure

each 37 mm long, which met at a right angle. The arrowheads were etched with a sharp needle and filled with black India ink. Each sheet was then buffed with a fine grade of commercial buffing compound to remove all dirt, cement, finger prints, et cetera, from the surfaces. Both sides of each sheet were covered with a commercial phonograph record cleaning fluid to prevent their becoming charged with static electricity and attracting dust. A pair of control plates was constructed in the same manner. These were identical to the plates containing the Müller-Lyer illusion figure in all respects except the actual figure. The standard control plate had two vertical lines 76 mm long and 153 mm apart. These lines passed through the space occupied by the points of the arrowheads on the standard illusion plate. The comparison control plate had one vertical line which also passed through the space occupied by the point of the arrowhead of the comparison illusion plate. Because of the fact that these two sets of lucite plates were identical in all dimensions it was possible to exchange them without the necessity of recalibrating the scale. This interchanging operation required approximately one hour. For this reason it was not practicable to assign *S*s to the experimental and control groups in a truly random fashion. It was decided to run all experimental *S*s before changing plates, and then to run the control *S*s. The lucite sheets were mounted on rollers with matching sets of rollers above them to insure a vertical position when moved. A stop was fastened to each end of the standard plate near the bottom so that the comparison plate could be moved a maximum of 77 mm to each side of the standard plate.

A locking device was mounted toward one end and on the top of the standard sheet. This consisted of a piece of sheet aluminum with three notches in the top. By depressing a lever into one of these notches it was possible to lock this plate into three positions, each 13 mm apart. A millimeter scale was also mounted on the top of the standard stimulus plate. An aluminum pointer mounted on the comparison stimulus plate allowed the difference between the positions of the standard and the comparison plates to be recorded in millimeters independently of the position of the standard sheet. The standard plate could be moved only by *E*, while the comparison plate could be moved by both *E* and *S*. The *S* could manipulate the comparison stimulus by turning a knob (centered below the facepiece) which activated the cable and pulley system connected to the comparison plate. The comparison arrowhead could be moved from an extreme position representing 125 mm of illusion through objective equality to an extreme position representing a negative illusion of 29 mm.

A light-proof vision tunnel served to eliminate extraneous visual cues. It was 708 mm long and constructed of plywood with the inside enameled white. The shutter (at the small end of the vision tunnel) was controlled by *E*. The inside measurement of the small end of this vision tunnel was 50 mm by 112 mm and the large end was 191 mm by 402 mm. Thus, *S*'s visual field was confined to the central portions of the lucite sheets. A homogenous background for the illusion figure was provided by a sheet of stiff white cardboard mounted on the rear wall of the box 168 mm behind the standard stimulus plate. Illumination for the visual field was provided by two 15 watt white fluorescent tubes (17 inches long) mounted on metal reflectors. These tubes and their reflectors were mounted in

the 168 mm space between the lucite sheets and the cardboard background. One of these bulbs was mounted below the lucite sheets and one was mounted above them so that the illumination of the visual field was homogenous.

A large vertical plywood screen separated *S* from the apparatus. An aperture 37 mm by 100 mm in this screen coincided with the small end of the vision tunnel and the shutter was mounted at this point. The facepiece was mounted 31 mm away from the screen so that the 15 watt white fluorescent tube (17 inches long) mounted above the facepiece prevented dark adaptation during the intertrial interval. The screen and facepiece were painted flat white. The *S* was seated in a chair, adjustable for height, and a footrest was provided. A small mirror was mounted on the wall above and behind *S* in order that *E* might observe *S*'s behavior at any time during the experiment.

Experimental design

Three values of exposure time and intertrial interval resulted in a three by three factorial design (Table 1). Each *S* received 30 trials on the first day, and eight trials 24 hours later. All trials for any individual *S* were identical in terms of exposure time and intertrial interval on both days. The conditions of cell three and cell seven were replicated with the control plates.

Subjects

The *S*s were assigned randomly to cells. There were eight *S*s in each cell, i.e., in each of the nine experimental and two control conditions. Thus, there were

TABLE 1

*Experimental Design**

Exposure time	Intertrial Interval					
	10 Sec.		20 Sec.		40 Sec.	
	Cell 1		Cell 2		Cell 3	
10 sec.	ET	10	ET	10	ET	10
	AP	5	AP	5	AP	5
	ITI	10	*ITI*	20	*ITI*	40
	Sum	25	Sum	35	Sum	55
	Cell 4		Cell 5		Cell 6	
20 sec.	ET	20	ET	20	ET	20
	AP	5	AP	5	AP	5
	ITI	10	*ITI*	20	*ITI*	40
	Sum	35	Sum	45	Sum	65
	Cell 7		Cell 8		Cell 9	
40 sec.	ET	40	ET	40	ET	40
	AP	5	AP	5	AP	5
	ITI	10	*ITI*	20	*ITI*	40
	Sum	55	Sum	65	Sum	85

* In each cell the total time per trial is broken down into its components of Exposure Time (ET), Adjustment Period (AP), and Intertrial Interval (ITI).

72 experimental and 16 control *S*s. An additional two *S*s were discarded before completion of the experimental task because they disobeyed instructions. Of the 88 *S*s retained, there were 49 males and 39 females. All were volunteers from introductory psychology courses at Indiana University. None of them wore glasses for any visual task except reading.

Stimulus conditions

Eight random orders of stimulus position were drawn. Each of these eight random orders was used once in each cell to determine the positions of the standard and comparison stimulus plates at the beginning of each trial.

Method

As the instructions were read to *S* they were clarified by reference to a small sketch of either the illusion or the control figure. Only the words "points," "arrowheads" and "lines" differed in the two sets of instructions read to the experimental and control *S*s. In brief, the *S*s were instructed to place the comparison arrowhead so that the distances between the points of the three arrowheads were equal. They were allowed five seconds to perform this manipulation. Each *S* was required to describe his task before actual experimentation began. The adequacy of this recitation was determined by reference to a check list. If *S* failed to describe his task adequately the appropriate portion of the instructions was re-read and all questions which could not be answered in this way were answered by the statement: "You do not need to know that in order to do your job."

Thirty trials were then administered to each *S*. Exposure times and intertrial intervals were controlled by means of a stop watch. The *S* was reminded to return the next day at the same time and asked not to discuss the experiment with other students who were enrolled in the introductory psychology course. When *S* returned for the second experimental session he was asked to describe his task and this recitation was again checked on the check list. Eight trials were then administered. Following this, *S* was asked if he had ever seen "anything like those three arrowheads before." If the answer was "yes" all feasible information was elicited (e.g., where, when, what was it, etc.) and recorded. The *S* was requested again not to speak about the experiment to other introductory psychology students.

RESULTS AND DISCUSSION

On every trial the position of the comparison stimulus plate was recorded to the nearest millimeter. If *S* had been responding to some extraneous cue (e.g., setting the comparison stimulus at a constant distance from the edge of the vision tunnel) this could be ascertained by examination of the response record. The position of the standard stimulus was randomly varied by exactly 13 mm through the use of the random orders of stimulus position. The criterion was established that any *S* whose responses varied by either 12, 13, or 14 mm from one trial to another as a function of the position of the standard would be discarded if this occurred on three or more trials. No *S* was discarded for this reason.

Experimental groups

The average amount of illusion by cells for all 38 trials is presented in Table 2. Collapsing rows indicated that, as predicted, there was a smaller amount of illusion associated with longer exposure times. Collapsing columns indicated that there was, as predicted, a larger amount of illusion associated with longer intertrial intervals. This finding was contradictory to the report of Köhler and Fishback that spacing of trials produced greater decrement.

Statistical analysis was performed on blocks of eight trials which were equivalent in terms of the positions of the standard and comparison stimuli. These blocks consisted of the first and last eight trials of day one, and the eight trials of day two. The settings made by each *S* were summed and averaged separately for each of these three blocks of eight trials. A trend test for repeated measures (Table 3) disclosed that intertrial interval and exposure time did not produce significant effects. Inspection of Table 2 had already indicated that the obtained differences did lie in the predicted directions, but that the differences were quite small.

Since the F value for blocks of trials was significant far beyond the .01 level of confidence, t tests were applied between the individual cells which made up

TABLE 2

Average Amount of Illusion by Cells in Millimeters for 38 Trials

Exposure time	Intertrial Interval			
	10 sec.	20 sec.	40 sec.	Mean
	Cell 1	Cell 2	Cell 3	
10 sec.	29	28	32	30
	Cell 4	Cell 5	Cell 6	
20 sec.	24	28	29	27
	Cell 7	Cell 8	Cell 9	
40 sec.	19	28	25	24
Mean	24	28	30	

TABLE 3

Summary Table of Trend Test Analysis

Source	*df*	Mean Square	*F*
Between Groups	8	19461.62	0.53
Between *S*s	63	36728.35	
Between Blocks	2	34782.80	12.19**
Interaction Groups x Blocks	16	2109.53	0.74
Interaction *S*s x Blocks	126	2853.39	
Total	215		

** Significant at the .01 level.

these columns (Table 4). The effect of repeated trials was primarily to produce decrement during the first session. Block two was of smaller magnitude than block one in all cases, and five of the six significant *t*s occurred between these two blocks.

Only one significant *t* was found between the two experimental sessions (blocks two and three), and this value was associated with a cell which exhibited spontaneous recovery of the illusion. Four of the cells exhibited spontaneous recovery, and only two exhibited decrement during the 24 hour period which separated the two sessions. The magnitude of illusion did not change for the three remaining cells. This finding cast doubt on Köhler and Fishback's conclusion that a 24 hour suspension of experimental operations produced further decrement in the magnitude of the illusion.

Examination of Fig. 2 indicated that spontaneous recovery of the illusion

TABLE 4

Cell Means and t Values for Three Blocks of Eight Trials

Cell	Block 1 Mean	*t* Block 1 Block 2	Block 2 Mean	*t* Block 2 Block 3	Block 3 Mean
1	29	0.49	27	0.71	29
2	34	1.42	26	0.18	26
3	36	7.97**	31	1.97	29
4	30	6.75**	22	4.40**	23
5	32	2.48*	26	0.56	26
6	37	1.80	26	1.15	27
7	26	2.16*	17	0.03	17
8	30	1.20	27	1.01	28
9	31	2.76*	22	0.48	20

* Significant at the .05 level.

** Significant at the .01 level.

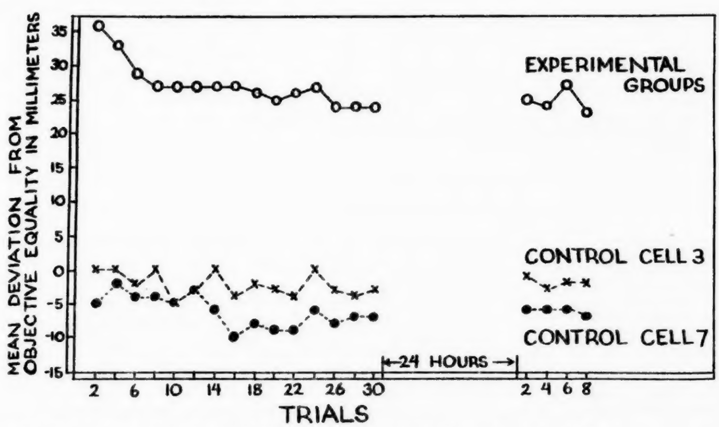

FIG. 2. Mean deviation from objective equality as a function of trials, days, and type of figure presented.

occurred when all 72 experimental *S*s were considered as a single group. However, the amount of recovery was quite small.

Control groups

The results obtained from the control groups were analyzed in a similar manner. The differences between these groups did not approach significance. Examination of Fig. 2 failed to reveal any systematic decrement. Thus, the decrements of the experimental groups are a function of the presence of the illusion figure.

Decrement and naiveté

On the basis of the answers given to the questions asked at the end of the second experimental session it was possible to dichotomize *S*s into *naive* and *not naive* groups. Any *S* who identified the illusion figure or indicated that the task was "tricky" or "misleading" was considered to be *not naive*. It was possible to further dichotomize *S*s in regard to their performance on the experimental task. Any *S* for whom the sum of the last eight trials on day one was smaller than the sum of the first eight trials was considered to have displayed *decrement*. Any *S* for whom these sums were equal or in the opposite relationship was considered to have displayed *no decrement*. Then the independence of naiveté and decrement was tested by means of a Chi square contingency test (Table 5). The two variables were independent. The independence of naiveté and the occurrence of decrement during the 24 hour period that elapsed between the first and second experimental sessions was tested in a similar manner (Table 6), and again the variables were independent. These two statistics indicated: (a) Differences in the results of this study and that of Köhler and Fishback (who used only naive *S*s) were not due to the use of both naive and sophisticated *S*s in the present

TABLE 5

Contingency Test for Independence of Naiveté and Decrement During First Session

	Decrement	No Decrement	Sums
Naive	fo = 24 (ft = 23)	fo = 9 (ft = 10)	33
Not naive	fo = 27 (ft = 28)	fo = 12 (ft = 11)	39
Sums	fo = 51 (ft = 51)	fo = 21 (ft = 21)	72

$\chi^2 = 0.27$ with 1 *df* (A value of 3.841 is necessary for rejection of the null hypothesis at the .05 level.)

TABLE 6

Contingency Test for Independence of Naiveté and Decrement Between Sessions

	Decrement	No Decrement	Sums
Naive	fo = 15 (ft = 16)	fo = 19 (ft = 18)	34
Not naive	fo = 20 (ft = 19)	fo = 18 (ft = 19)	38
Sums	fo = 35 (ft = 35)	fo = 37 (ft = 37)	72

$\chi^2 = 0.22$ with 1 *df* (A value of 3.841 is necessary for rejection of the null hypothesis at the .05 level.)

study. (b) Decrement in magnitude of illusion during a 24 hour suspension of experimentation is not a group phenomenon.

General considerations

The performances of individual *S*s were quite variable during both the first and second experimental sessions. In terms of a visual inspection of the individual records it appears to be possible to select a small number of cases in order to "prove" that the amount of illusion either increased, decreased, or remained essentially the same during either the first experimental session, the second experimental session, or the 24 hour period that elapsed between these two sessions. Possibly such random fluctuations as these have been misinterpreted by Köhler and Fishback since a small sample might conceivably have contained a disproportionate representation of those *S*s who do exhibit decrement following the 24 hour suspension of experimentation.

The conclusion that a 24 hour suspension of experimentation does not result in decrement in the illusion response is in direct conflict with the study of Köhler and Fishback. In the introductory section of this paper it was pointed out that none of the previously published studies were adequate when judged by modern standards. For example, there were no controls for individual differences between *S*s. In the case of the present study a more secure generalization may be drawn since these objections have been overcome. Individual differences were controlled by using a large sample of *S*s and by randomly assigning these *S*s to experimental conditions. The experimental conditions were carefully controlled. Random fluctuations were controlled by statistical analysis of the data. It was especially this control of random fluctuations by statistical evaluation which indicated the possibility of error in Köhler and Fishback's conclusion that a 24 hour delay period resulted in a drop in the amount of illusion. Further studies must utilize the improved techniques which are now available to the researcher. The need for continued research is indicated by failure to confirm either Köhler and Fishback's conclusions or the predictions made on the basis of the habituation paradigm.

SUMMARY AND CONCLUSIONS

In a study of response decrement to the Müller-Lyer illusion figure it was found that:

1. Statistically significant decrement in the magnitude of illusion occurred as a function of trials even though no information was given to *S*s concerning the accuracy of their responses.
2. The magnitude of the illusion tended to be greater with increasing intertrial intervals, though this was not statistically significant.
3. The magnitude of the illusion tended to be smaller with increasing exposure times per trial, though this was not statistically significant.
4. There was a tendency for spontaneous recovery of the illusion during a 24 hour suspension of experimentation.
5. The naiveté or sophistication of *S*s concerning the illusion figure was not

related to the occurrence of decrement, either during the first session or the 24 hour period between sessions.

6. No decision can be made as to whether decrement to the illusion figure is a type of figural after effect or an habituation process.

7. It was suggested that marked individual differences between *S*s required the use of large numbers of *S*s and precise experimental and statistical controls for future research on this phenomenon.

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DECREMENT TO THE VERTICAL-HORIZONTAL ILLUSION FIGURE

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Renewed interest in the well known decrements to the Müller-Lyer figure has resulted from the attempt of Köhler and Fishback (3, 4) to account for these decrements in terms of satiation theory. Selkin and Wertheimer (7) reported no difference between *S*s instructed to use a fixation point and those who were not required to fixate their regard. Selkin and Wertheimer correctly consider this result to be a predictive failure of the Köhler and Fishback satiation theory. Mountjoy (5, 6) verified certain of Köhler and Fishback's findings and failed to verify certain other features of their report. Mountjoy also interpreted his results as evidence that decrements to the Müller-Lyer figure were a learning phenomenon instead of a type of figural after effect. The learning process to which these decrements seem to be related is the extinction-like process known as habituation (2).

A further test of the relative ability of the satiation theory and the habituation hypothesis to account for decrements to illusion figures is the extension of research to other optical illusions. The geometrical illusions are promising areas for further research because of the case of making quantitative measurements of the magnitude of the illusion. The vertical-horizontal figure was selected since its form does not appear to allow the satiation theory to predict the occurrence of decrement. However, the habituation hypothesis predicts that decrements will be a function of repeated trials in a manner analogous to decrements reported for the Müller-Lyer figure. The habituation hypothesis prediction follows from the presence of the illusion response and is independent of the form of the figure used.

Farnum (1) and Valentine (8) reported the occurrence of decrement to the vertical-horizontal figure, while Williams (10) reported that no decrement occurred for his *S*s. Because of these conflicting reports and Mountjoy's previous failure to verify certain of the results reported in the older literature on the Müller-Lyer figure it was decided to determine whether decrement did occur to the vertical-horizontal figure when *E* utilized modern experimental and statistical methodology.

A secondary hypothesis was the effect of various intertrial tasks on the rate of decrement. The habituation hypothesis (6) predicts that movement produced stimulation delays decrement in a manner analogous to the dehabituation of a habituated response (or the disinhibition of an extinguished response).

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PROCEDURE

Apparatus

The figure consisted of two mimeographed lines on a sheet of mimeo bond 217 mm by 356 mm. The horizontal line of 154 mm was either 30 mm, 50 mm, or 70 mm from the bottom of the sheet while the vertical line always extended to the top of the paper.

Method

Each *S* was given 21 trials. Each of the three positions of the horizontal line occurred once in every block of three trials for each *S*. However, each position occurred an equal number of times on any single trial for the entire group of *S*s. Thus the position of the standard stimulus was randomized for each *S* but counterbalanced for each trial. The *S* was instructed to make a pencil mark at the point where the vertical line appeared to be of the same length as the horizontal line. The *S* was allowed five seconds to respond and a constant intertrial interval of 55 seconds was maintained throughout the experiment.

The *S*s were randomly assigned to three groups. Group I was instructed to fixate a large square of white cardboard, which was fastened to the wall directly in front of them, during the intertrial interval. Groups II and III were presented with portions of a prose selection during the interval and instructed that they would be interrogated for retention and understanding at the end of the session. Group II read the story and Group III heard the story by tape recorder. There were 15 *S*s in each group.

Subjects

Data were obtained from 45 student volunteers of both sexes from the introductory psychology course at Denison University. One *S* was discarded and replaced for failure to obey instructions.

RESULTS AND DISCUSSION

The intertrial tasks given to the *S*s appeared to have no effect on the occurrence of decrement to the vertical-horizontal figure and will not be discussed further.

Inspection of Fig. 1 indicated that decrement did occur as a function of repeated trials even though no information was given to *S*s concerning the accuracy of their responses. The t value (for paired measures) between block one and block seven was significant at the .05 level of confidence (2.20 with 44 *df*). It should be noted that approximately half of the *S*s actually displayed a decrement when the magnitude of illusion on block one was compared to that on block seven. There were 23 *S*s (51%) who exhibited decrement, 19 *S*s (42%) who displayed an increase in the amount of illusion, and 3 *S*s (7%) for whom the value of block one and block seven were equal. In contrast to this, Mountjoy (5) found in his first investigation of the Müller-Lyer illusion that 51 *S*s (71%) showed decrement and 21 *S*s (29%) either increased in the amount of illusion or showed no change. In his later study of the Müller-Lyer figure Mountjoy (5)

reported that 172 *S*s (87%) displayed decrement while 26 *S*s (13%) exhibited either an increment in magnitude or no change. The small number of *S*s who decremented to the vertical-horizontal figure might be a function of the number of trials. It was decided to give only 21 trials because in his previous studies of the Müller-Lyer figure Mountjoy found that his groups appeared to be asymptotic after about 20 trials. Possibly individual *S*s displayed further decrement after the group curve had reached an apparent asymptote. (See Table 1.)

A horizontal line of 154 mm was used in the present study to allow comparison to Mountjoy's findings for the Müller-Lyer figure as he had used a standard stimulus of that magnitude. Examination of Table 1 indicated that although the

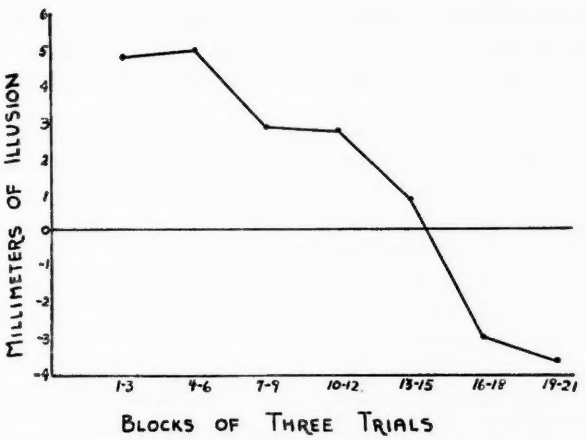

FIG. 1. Mean millimeters of illusion as a function of trials

TABLE 1

Comparison of Vertical-Horizontal Illusion Magnitude with Müller-Lyer Illusion Magnitude

Each value is given both as mean millimeters of illusion and as mean per cent of the standard stimulus.

	Trial 1	Last Block of Trials	Decrement	Total No. of Trials
Vertical-Horizontal Figure* $N = 45$	6.73 mm (4%)	−3.60 mm (−2%)	10.33 mm (6%)	21
Müller-Lyer Figure† $N = 72$	36.26 mm (23%)	23.99 mm (15%)	12.27 mm (8%)	30
Müller-Lyer Figure‡ $N = 90$	48.21 mm (31%)	26.39 mm (17%)	21.82 mm (14%)	31

* Data from present study.

† Data from Mountjoy (5). The initial value is lower than the other Müller-Lyer study because *S*s received a preadjustment exposure period.

‡ Data from Mountjoy (6). The *S*s did not have a preadjustment exposure period.

standard stimulus was of the same magnitude in all three studies, the values of the comparison stimulus appeared to be a function of the illusion figure used in the particular study. The magnitude of the illusion was greater for the Müller-Lyer figure at all times, and more decrement occurred to that figure than to the vertical-horizontal figure. Walters (9) reported that the vertical-horizontal figure produced a larger magnitude of illusion than did the Müller-Lyer figure. It is possible that the mimeographed illusion used in the present study depressed the initial magnitude.

Köhler and Fishback (3, 4) have reported below zero values for the Müller-Lyer figure and referred to this phenomenon as a "negative illusion." Mountjoy (5, 6) failed to obtain this negative illusion as a group phenomenon in his studies of the Müller-Lyer figure, although it was observed in the case of individual *S*s. Examination of both Fig. 1 and Table 1 indicated that a negative illusion was present for the group of *S*s exposed to the vertical-horizontal illusion in the present study.

The form of the curve of decrement for the Müller-Lyer figure has been reported to be a negatively accelerated function of trials (5, 6). The curve for the vertical-horizontal illusion was instead a positively accelerated function of trials (Fig. 1).

SUMMARY AND CONCLUSIONS

Statistically significant decrement was found to occur as a function of repeated trials with the vertical-horizontal illusion figure. Although such decrements have previously been reported for the Müller-Lyer figure, the two phenomena were not identical functions. Further research is planned to determine whether the differences in decrement to these two illusion figures is a function of the figures themselves or of variations in procedural detail.

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THE EFFECTS OF EARLY TRAINING ON LATER RESPONSE EFFICIENCY[1]

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I. INTRODUCTION

It has been apparent that the early environment in which an organism develops is a crucial determinant of later behavior. Since the time of Aristotle (1) naturalists have speculated about the possible importance of early learning in the lives of lower vertebrates. The belief that experience early in the life of an organism can affect the behavior of the adult has led to recent experimental tests (10, 12, 13, 24) and literature reviews (2, 17, 27). To be included also is the renewed interest in the effect of prenatal environment (28).

Most experiments on early training probably were stimulated by the theories of Freud (7) and Hebb (11). Freud's influence in this area is illustrated by the various studies which limited the food supply and feeding responses in young animals (12, 21, 22), experiments involving stress-situations (8, 19, 23, 25), and the reduction of stress through early handling procedures (18, 19, 23). Most stress experiments are designed to provide a traumatic experience for the developing organism and to measure the effect of the experience on learning (8, 19, 25) or emotional behavior (10, 23). On the other hand the gentling experiments (18, 19, 32, 33) are designed to reduce stress in the early period.

Hebb's theory which stresses the importance of perceptual learning in infancy upon subsequent learning has influenced many experimental designs which modify the environment of the young subject. These modifications may be either (a) to increase the environmental complexity and stimulation by elaborate "animal playgrounds", or (b) to restrict the environment of the subject by reducing the normal environmental stimulation available to the developing organism (3, 6, 13, 29, 30).

A third important influence has been the theories of Lorenz and other European biologists who emphasize the effects of early social stimulation upon adult behavior of various species of birds. Recent experiments have provided some type of social isolation (5, 31), crowded social conditions (5), or exposure of the developing organism to an aggressive (16) or sexual (15) situation.

II. PROBLEM

The hypothesis that some type of early experience can influence behavior is generally accepted. What is not so obvious are the "causal" factors that operate to produce the effects on later behavior.

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The manipulations involved in many early experience studies are usually so general (handling, shocking, restricting, et cetera) that it is difficult to separate out relevant and specific independent variables. Furthermore most of the investigations test the effects of these manipulations by tasks different from those involved in the early training.

The present study, primarily methodological, sought to satisfy these two conditions by employing the Skinner (26) operant conditioning procedure. This provided careful control of specific independent variables during early training and use of the same performance measure (bar pressing) during early training that is used in the later test of its effect.

To produce different conditions during early training varying the age of the *S*s was considered but rejected in favor of drugs (a stimulant and a depressant). Thus the present research is designed to investigate the influence of different psychopharmacological conditions upon *S*s undergoing operant conditioning and the effect later without drugs upon operant behavior and extinction.

III. PROCEDURE

Apparatus

Four modified Skinner boxes comparable to those of Guttman and Estes (9) were used. A removable aluminum lever five cm. wide could be presented through a slot in the cage wall nine cm. above the floor. Movement of the lever downward a distance of one-fourth inch, with a force of four grams, activated the magazine motor. The magazine consisted of a tiny brass cup soldered to an aluminum arm which was attached to the motor. The cup was always present at the aperture in the floor except when the motor was operating. During conditioning depressing the lever caused the cup to dip into a reservoir and to present at the aperture four mg. of tap water. During extinction lever depression caused the magazine motor to present the same visual and auditory cues as during conditioning. The time in seconds required for each animal to receive 100 reinforcements was recorded.

Drugs and injections

The following concentrations of drugs were used: (a) benzedrine—.66 mg. per kilogram of body weight, (b) chlorpromazine[3]—.50 mg. per kilogram of body weight, and (c) injection water—U.S.P. with 0.5% benzyl alcohol. B-D Yale Tuberculine syringes and B-D Yale Regular point hypodermic needles (Luer-Lok-27G-⅜″) were used for administering the drugs.

The injection procedure was as follows: The *S* assigned to box A was placed on the table and held by the assistant while *E* administered an intraperitoneal injection. The needle was inserted with a quick thrusting motion just above Paupart's Ligament and the point pushed down and upward about an inch in the direction of the head. The *S* was replaced in the restraining box and the same procedures followed for the other animals to be run during the same hour.

[3] Chlorpromazine (Thorazine) was supplied by the Smith, Kline and French Laboratory, Philadelphia, Pa.

The daily injections took approximately five minutes. The amount of fluid (dosage) each *S* received was determined by his body weight. After completing the injections each *S* was placed in the appropriate Skinner box. The same procedure was followed each day during the early training period. After the daily trials the *S*s were given access to water during the following hour thus maintaining the 22 hour deprivation schedule.

Subjects

Twenty-four naive male albino rats comprised the Unit A subjects which were randomly assigned to the benzedrine, chlorpromazine, and control groups. Twenty-four additional animals were randomly assigned in a similar manner within Unit B. All animals were 90 days old at the beginning of experimental trials. The division of the three experimental groups into two running units, A and B, was arranged so that all *S*s in a unit could be run daily with the time and apparatus available.

The benzedrine *S*s in Unit A did not condition when injected with a concentration of 1.33 mg. per kilogram of body weight and were discarded. Twelve additional animals were assigned to the B experimental unit and injected with benzedrine (.66 mg. per kilogram of body weight).

Pre-training

The *S*s were placed on a 22 hour water deprivation schedule and handled by the *E* six days before the experimental trials. For two days the *S*s were exposed to the weighing procedure. In the third, fourth, and fifth days the *S*s were weighed, placed in a cardboard box, and dipper trained in the Skinner box with the lever removed. Twenty reinforcements were given at irregular intervals during one hour. On the sixth day the *S*s were injected and then dipper trained under the various experimental conditions.

Experimental Trials

On the seventh day the *S*s of Unit A began their experimental trials and the lever was presented for the first time. The *S* (under 22 hour deprivation) was placed in the box for the initial series of 100 reinforcements. The time required for these 100 reinforcements was recorded and the animal was removed from the box. If at the end of one hour the animal had not received 100 reinforcements he was discarded. All *S*s were trained for 14 days under the three experimental conditions. Since three or four animals were run simultaneously, it was not always possible to stop each animal after exactly 100 daily reinforcements. The balance was restored the following experimental day so that each animal at the end of the early training period had received approximately 1400 reinforcements (with a maximum error of one).

After the early training period of 14 days the *S*s in Unit A were returned to their home cages and placed on an *ad lib* water schedule for 14 days. From the 15th to the 22nd day of the neutral (rest) period the *S*s were again placed on a 22 hour deprivation schedule. Thus the *S*s were given 22 days for any physio-

logical effects of the drugs to wear off. Every other day during the neutral period the *S*s were removed from their cages by *E* and placed in the cardboard box for approximately five minutes.

After the 22 day neutral period the *S*s were given later training trials for 14 days (100 reinforcements per day). The same procedure was followed during these later trials except the *S*s were not injected. On the 4th day of later training the *S*s were not run because of a mechanical failure in the control box.

Following this later training the *S*s were given three days of extinction and the total number of responses emitted by *S* during each one hour experimental session was recorded.

Unit B followed the same schedule 20 days after Unit A. Table I presents the complete experimental program.

IV. RESULTS

The data consist of the time required for each animal to receive 100 daily reinforcements during the early and later training phases (14 days each) and the number of lever depressions during each hour of extinction (three days).

Early Training

Figure 1A depicts the mean time required for the subjects of the experimental groups to receive 100 reinforcements during each of the 14 days of early training. The benzedrine and chlorpromazine groups took considerably more time than the control group to obtain the 100 reinforcements for the first day. This dis-

TABLE I
Experimental Program

90 day old Unit A *S*s		70 day old Unit B *S*s	
Handling	2 Days	In Laboratory	
Dipper Training	3 Days		
Dipper Training (drugs)	1 Day		
Early Training Period (drugs)	14 Days		
Neutral Period (rest)	22 Days	Handling	2 Days
		Dipper Training	3 Days
		Dipper Training (drugs)	1 Day
		Early Training Period (drugs)	14 Days
Later Training	3 Days	Neutral Period (rest)	22 Days
Mechanical Failure	1 Day		
Later Training	11 Days		
Extinction	3 Days		
		Later Training	3 Days
		Simulated Unit A's Mechanical Failure	1 Day
		Later Training	11 Days
		Extinction	3 Days

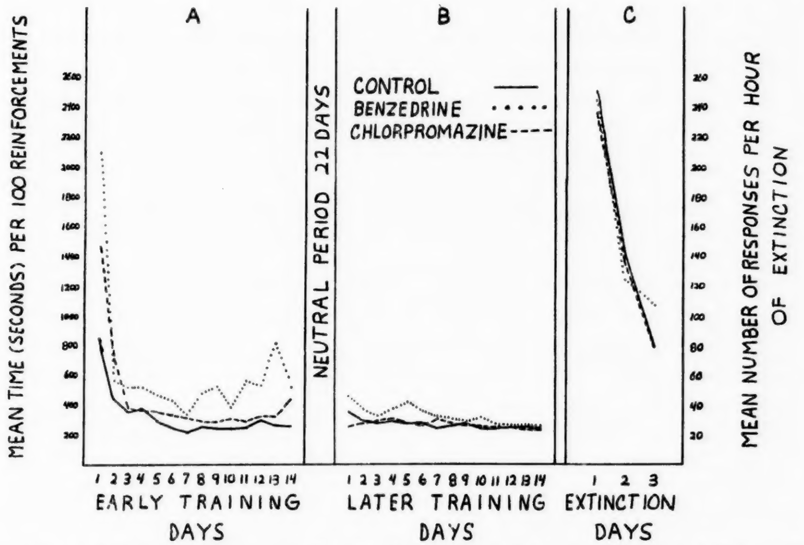

FIG. 1. Means of Performance Time during Early and Later Training and Response during Extinction of Control, Chlorpromazine, and Benzedrine Groups.

crepancy decreased on the second and third days although with one exception (second day) the mean times remained in the same relationship. From the 7th to the 14th day there was a decrease in the rate of responding of the benzedrine group.

Table II summarizes the analysis of variance of the performance times of the three experimental groups during the early training period. Significant *F*s ($p <$ .05) were obtained between the effects of the drugs, between trials, and for the interaction of trials and drugs.[4]

The null hypothesis that there is no significant difference during the early training period between the three experimental groups was rejected.

Later Training

After the neutral period of 22 days training was resumed for 14 days. The conditions were the same for all three groups, that is, there were no further injections. Figure 1B shows that the group receiving benzedrine during early training still responded slower than the chlorpromazine and control groups which were quite similar.

Table II summarizes the analysis of variance of the performance times for the three experimental groups during the later training period. Significant *F*s ($p <$ .05) were obtained between the groups trained under the three conditions, between trials, and for the interaction of trials and drugs.

[4] The analysis of variance technique for repeated measurements on several independent groups as described by Edwards was used ((4), pp. 284–303).

TABLE II

Summaries of Analysis of Variance of Performance Time during Early and Later Training and Responses during Extinction of Control, Chlorpromazine, and Benzedrine Groups

Source of Variation	Early Training Period				Later Training Period				Extinction			
	Sum of squares	*df*	Mean square	*F*	Sum of squares	*df*	Mean square	*F*	Sum of squares	*df*	Mean square	*F*
Between groups	7516894	2	3758447	9.94	351505	2	175753	5.85	1691	2	846	.074
Between subjects in the same group	11340024	30	378001		902024	30	30067		342061	30	11402	
Total between subjects	18856918	32			1253529	32			343752	32		
Between Trials (1–14)	38324757	13	2948058	30.58	442639	13	34049	5.77	419285	2	209643	72.74
Interaction: Trials × Drugs	6879758	26	264606	2.74	306137	26	11775	1.995	7579	4	1895	.658
Interaction: pooled subjects × trials	37681928	390	96620		2301102	390	5900		172939	60	2882	
Total within subjects	82886443	429			3049878	429			599803	66		
Total	101743361	461			4303407	461			943555	98		

The null hypothesis that there is no significant difference during the later training period between the three groups trained under different conditions was rejected.

A comparison of Figure 1A and 1B shows an inversion of the chlorpromazine and control groups between the last two days of early training and the first two days of the later training. During the last two days of early training the chlorpromazine *S*s appear to be responding more slowly than the control group but were responding faster during the first two days of later training.

Extinction

After receiving approximately 2800 reinforcements (maximum error of five) during the early and later training periods the *S*s in the three experimental groups were given extinction trials for three days. In Figure 1C the mean number of responses emitted by each of the groups during the daily one hour extinction trial is shown. During extinction there was no significant difference ($p > .05$) between the three groups trained under the various conditions and in the interaction of trials and drugs.

The curves of the three groups are practically identical during the first two days of extinction. On the third day, however, the benzedrine *S*s emitted a total

of 1200 bar presses while those in the chlorpromazine and control groups responded approximately 800 times. The extinction curve of the control group was biased by an atypical *S*. One control animal emitted 1098 responses during the three day extinction period (only *S* over 750 responses) contributing over one-fifth of the total number of responses for the group.

V. DISCUSSION

Most investigations of the effect of early experience upon later performance studied different classes of behavior in the two phases. The present study, essentially methodological in approach, utilized the same response, bar pressing, during both early training and the later testing period.

The approach seems feasible for study of additional factors. There were statistically significant differences between the three experimental groups during early training (S-R analysis) and during later training after elimination of the drug conditions. The latter may be regarded as an R-R type of analysis if it is assumed that these later differences were a function of the earlier behavior rather than of significant, persisting organic changes in the originally drugged *S*s.

The effect of the early training was further modified during the later period. This practice effect was most apparent in the benzedrine animals as the three curves approached each other during the last three days of later training (Figure 1B).

The neutral period of 22 days (between early and later training) was assumed to be adequate for any prolonged organic effects of the drugs to wear off. After the first three days of injections during the early training period it was difficult to distinguish between the drugged and control *S*s by general observation. Whether any persisting anatomical or physiological changes occurred in the benzedrine and chlorpromazine animals was not investigated in the present study.

There was no significant difference between the experimental groups during the extinction period. On the last day of extinction, however, the benzedrine *S*s emitted approximately 400 more bar responses than either the control or chlorpromazine *S*s. (Figure 1C.) This leads to a hypothesis requiring empirical testing, namely that any difference in the rate of responding during extinction between the three groups does not become apparent until after the third day. The benzedrine *S*s may be more resistive to extinction but require additional days for the effect to become apparent.

It is difficult to evaluate the role of practice in the present experiment, that is, any effect on extinction of the early training under the drug conditions may be obscured by possible equalizing effects of continued training in both periods beyond the time when the drugs had their maximum influence.

In all studies such as this one it is difficult to evaluate the role of the drug conditions (14). Was there some general effect upon learned behavior, or, did the drugs alter the value of the water as a reinforcing condition? Gross observation following the experimental trials suggested that the drugged animals responded no differently to water given in the home cages than did the control animals.

Whatever the effect during early training different performance levels appeared during the later training when the conditions for all animals were the same except the nature of early training.

Further research within the framework of the present experimental design is necessary before any conclusive statements can be made concerning the precise effect of early training on later training levels and extinction. Drug concentrations during early training, the number of daily reinforcements, the number of trials, the length of the neutral period, the placing of extinction (*S*s could be extinguished for 14 days immediately after the neutral period), schedules of reinforcement, and so forth, could easily be manipulated. Varying the length of the training period to study the effects of continued practice would seem to be indicated particularly from the present data. Cessation after three days when maximal difference appeared among the groups (perhaps before some adaptation to the drugs) followed by a neutral period, further training and extinction, or by extinction without a later training phase might provide a more sensitive measure of behavior modifications induced by the early training conditions.

VI. SUMMARY

The present experiment was primarily a methodological approach to the early training problem. In this study instead of making the quality of the early experience and the nature of the later performance task different (as in most experiments) the same response, bar pressing, was utilized in early training and in testing later behavior.

During the early training period (14 days) three groups of albino rats (N = 11 in each) learned the task under the influence of two drugs (benzedrine and chlorpromazine) and injected water. Following a neutral period of 22 days the *S*s were run for 14 more days (without the drug conditions) and then the bar pressing was extinguished for three days.

There was a statistically significant difference between the three experimental groups during the early and later training periods. There was no statistically significant difference between the groups during extinction.

Possibilities for further research within the framework of the present experimental design were discussed.

VII. ACKNOWLEDGMENTS

The author is grateful to the Denison Research Foundation for a financial grant which supported this work. The author also wishes to express his gratitude to Dr. Irvin S. Wolf and Dr. Paul T. Mountjoy for their help in the formulation and execution of this study, and to Mr. Thomas Warm for his able assistance in the collection of the data.

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